AN OVERVIEW OF NON-METALLIC BRUSH SEAL TECHNOLOGY

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Abstract: Non-metallic brush seals are ultra-low flow sealing elements ideal for low pressure differentials (<30 psid) and low temperature (typically <300 degF) applications. The compliant bristle pack of a non-metallic brush seal is advantageous in terms of sealing capability during transients. However, if not designed properly, the bristle pack compliance can be detrimental to the performance of the seal. GE GLobal Research has investigated the stiffness and heat generation properties of non-metallic brush seals made from Kevlar and Carbon Fiber. The presentation will review the progress made on the design points of the seals, as well as highlight some current commercial applications of the technology.

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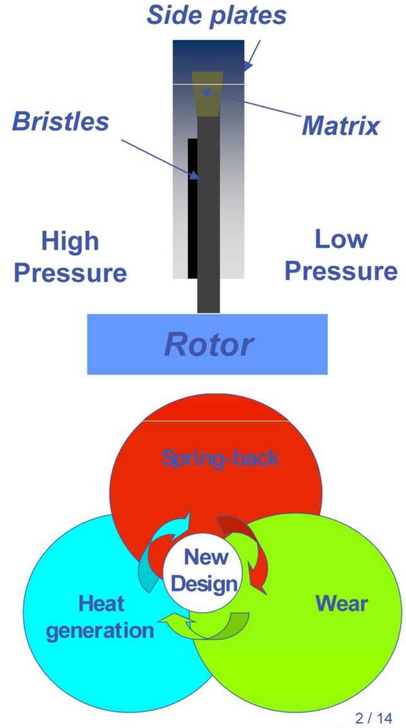
Why non-metallic brush seals?

- Excellent sealing (< 0.002” effective clearance)
- Wear particulate benign in bearing environment
- Good oil preclusion properties
- Compliant bristle pack
  - No rotor scoring or marking
  - Source of heat generation
  - Wear debris caused by stiffness



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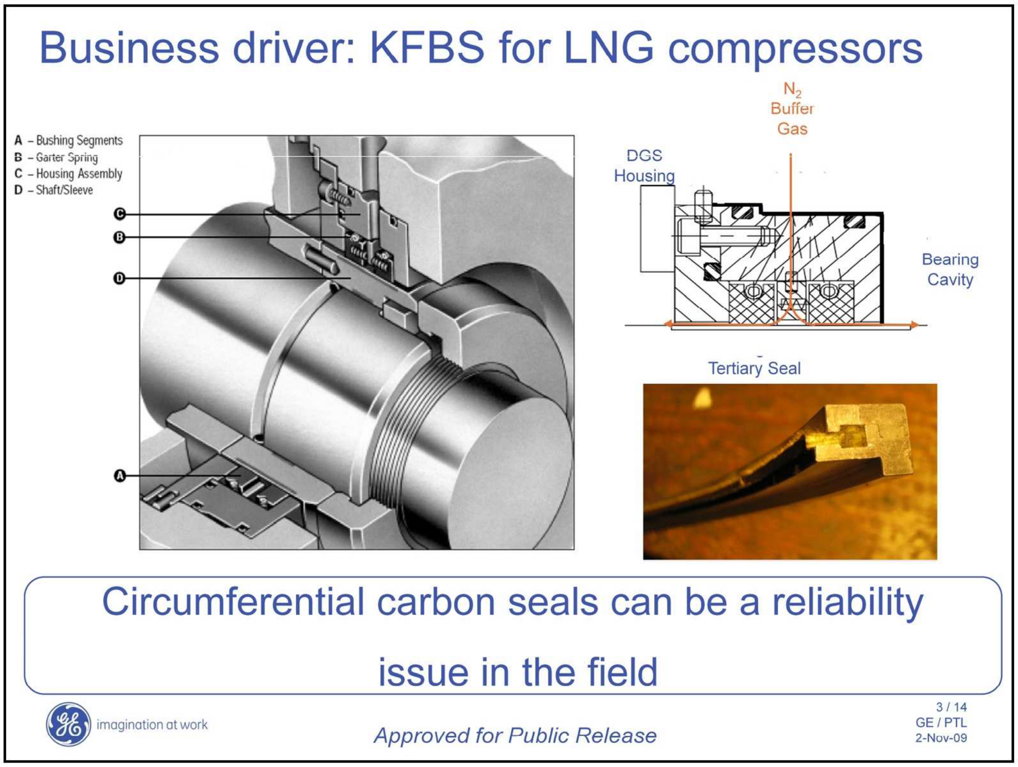
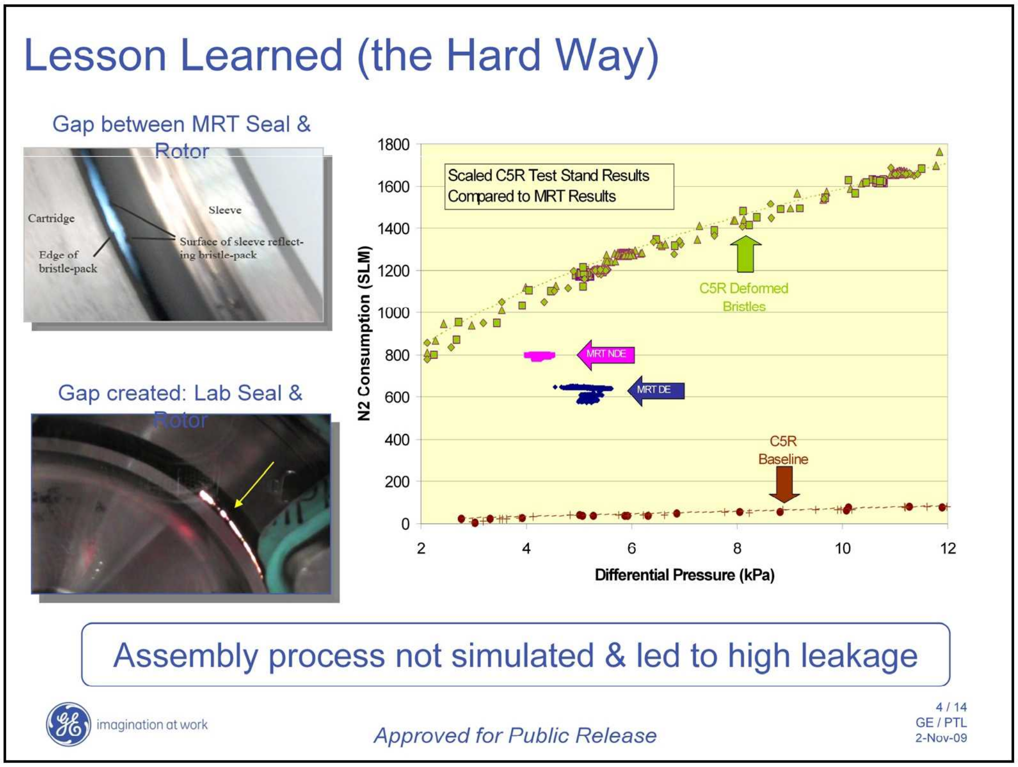
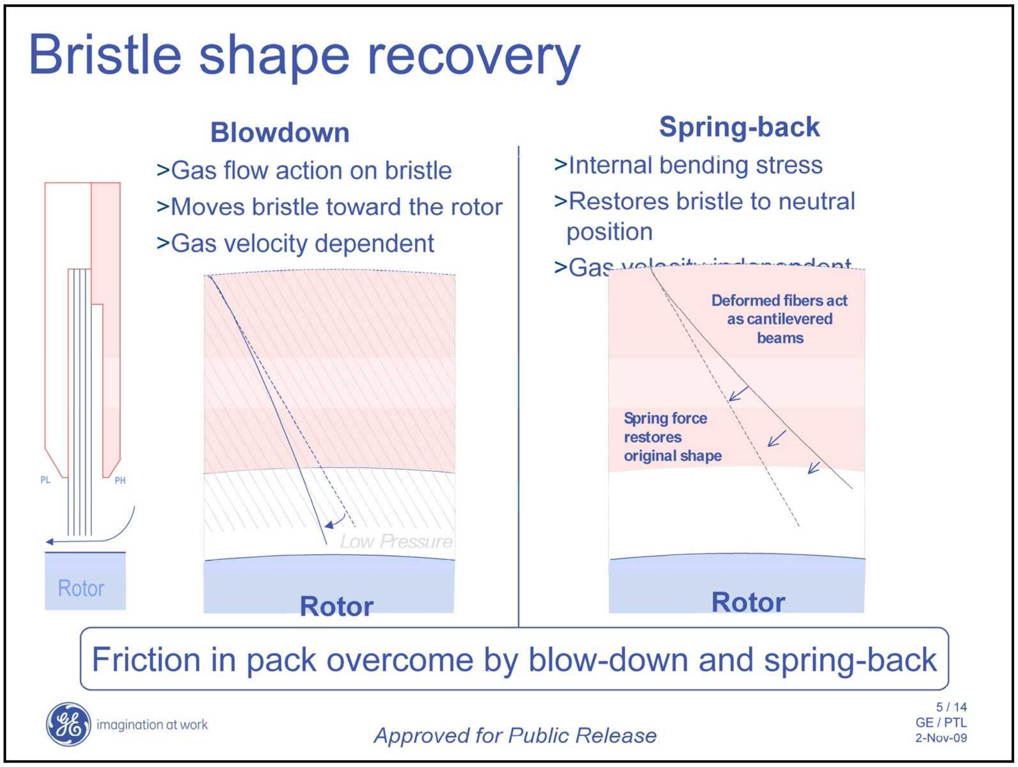


GE Oil & Gas was not the primary business driver in the initial development of non-metallic brush seals. However, GE O&G was the first to heavily invest in the technology development to ensure a robust seal design.

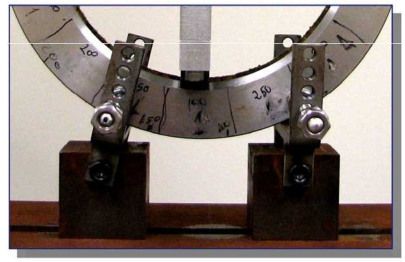


Early 2007 field trial had high leakage. RCA following the field trial failure revealed that the bristle pack was poorly designed—it was too soft from a stiffness perspective. The assembly process of getting the seals onto the rotor was never simulated in the subscale testing, thus never identified as a potential issue prior to field testing.



There are two main factors that affect bristle pack recoverability: blow-down and spring-back. The focus of this research is on spring-back, as it is a property inherent to the seal design and not a function of differential pressure.

Spring-back quantification



- Insert / Retract Rate: 0.25mm/s
- Cycles per test point:
  - 4 in initial testing
  - 10 in subsequent testing
- Maximum compression: 0.9 mm
- Output: Load vs. displacement curves generated

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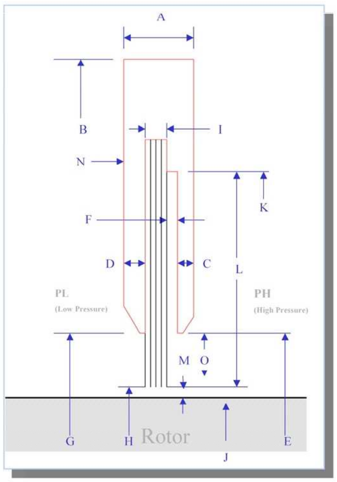
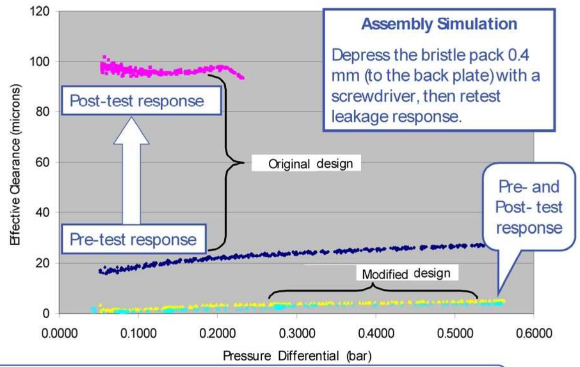
Spring-back test setup at GE GR in Niskayuna, NY.

Design changes & results

Parameter	Label	% Original
Fiber Free Length	L	31%
Bristle-Rotor Interference	M	146%





Modified bristle design improved Springback and leakage

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Identified design changes to improve the stiffness of the bristle pack led to a successful second attempt both in the subscale and in a field trial.

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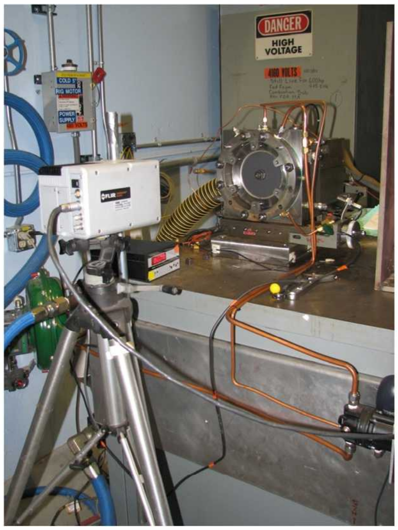
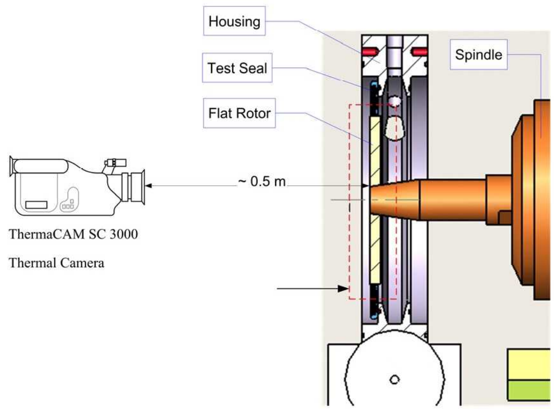
Heat generation testing: setup





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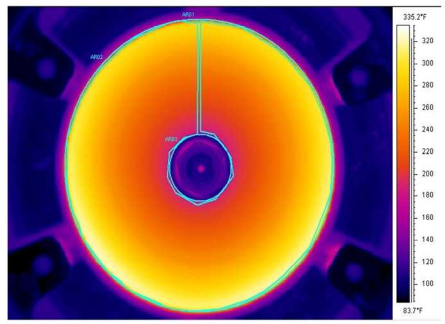
Heat generation testing setup at GE GR, Niskayuna, NY.

Heat generation test procedure

1. Set rotor speed
2. Monitor average temperature at inner 1” diameter of rotor
3. Record thermal gradient throughout rotor once steady-state conditions are met
4. Increase rotor speed



Test Conditions:

> 7, 33, 67, and 100% rpm

> Clearance, L-L, and Int

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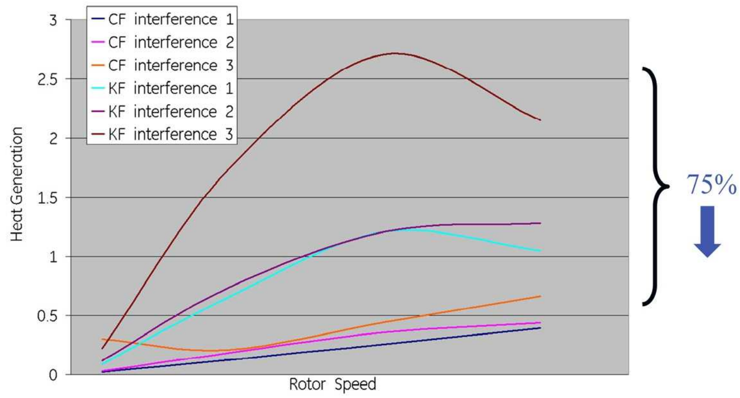
Carbon fiber outperforms Kevlar fiber for reduced heat generation



75% reduction in heat generation compared to Kevlar fibers

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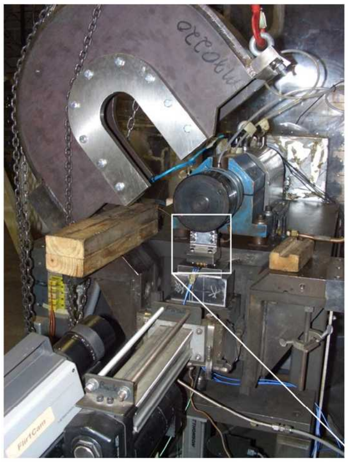
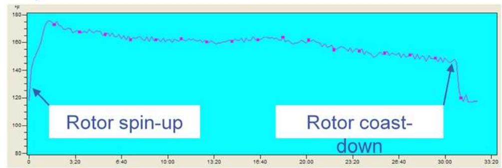
Seal designs were similar for both carbon and kevlar fiber.

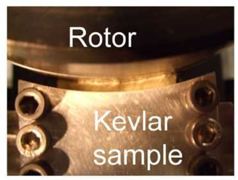
Wear testing results

At maximum running speed, bristle pack interference will wear completely within 30 minutes.



IR camera captures initial thermal spike and roll-off as fibers wear





→ Second phase of testing to investigate slow-roll running conditions.

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Wear testing setup at GE GR in Niskayuna, NY.

Carbon Fiber versus Kevlar Fiber

Property	Kevlar	Carbon
Fiber diameter		
Heat generation		
Sealing pressure		
Sealing temperature		
Seal manufacturability		
Final bore cut		
Bristle pack robustness		
Field experience		

= best

= neutral

= poor

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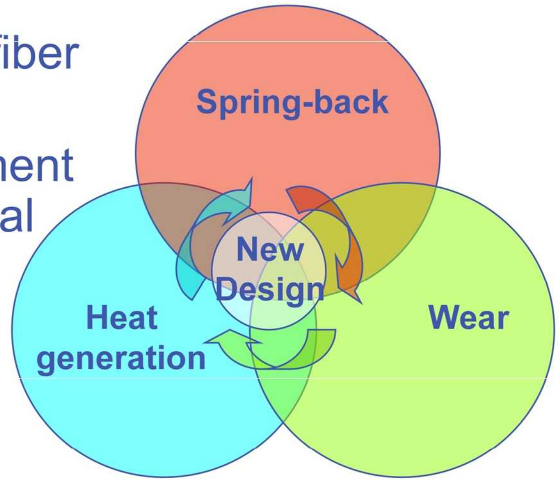
This table compares the identified property in the leftmost column between both the kevlar and carbon seal designs. Since it is comparing just these two seals, each row compares the stated property, where one seal is usually identified as being better or worse than the other.

Summary

- Choice of Carbon or Kevlar fiber is application specific
- Kevlar seal design development more mature than carbon seal equivalent
- Carbon fiber has better heat generation characteristics
- Kevlar fiber has field-demonstrated robustness to rotor transients



Next steps: Focus on application deployment for Kevlar seals & continued development of carbon fiber seals

References

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